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(54) IMPROVEMENTS IN AND RELATING TO DIVING APPARATUS

(71) We, SIEBE GORMAN & COMPANY LIMITED, a British Company, of Davis Road, Chessington, Surrey, do hereby declare the invention, for which we pray that a patent may be granted to us, and the method by which it is to be performed, to be particularly described in and by the following statement:—

The invention relates to diving apparatus.

The invention provides a diving helmet which includes inflatable means arranged to form a seal around the face of a wearer, thereby isolating a region of the interior of the helmet that is accessible to respirable gas from the remainder of the interior, and valve means arranged to allow the quantity of gas in the sealing means to be regulated to vary the fit of the helmet and/or to compensate for ambient pressure changes.

The invention also provides a combination of such a diving helmet with a so-called "dry" diving suit in which the interior of the suit is in communication with the said remainder of the interior of the helmet and not with the region accessible to respirable gas. Advantageously, the diving suit is inflatable and additional valve means is provided which, in use, allows communication between the interior of the diving suit and a source of compressed gas, and is also capable of allowing gas to pass from the interior of the diving suit to the exterior. Preferably, the said additional valve means includes a pressure-sensitive valve arranged to allow gas to pass from the interior of the diving suit to the exterior when the pressure of the gas in the diving suit exceeds the ambient pressure by a predetermined amount. Advantageously, the said pressure-sensitive valve is located in the diving helmet.

The source of compressed gas used for inflating the diving suit may be the source of gas used for respiration. The provision of sealing means arranged to isolate a region of the interior of the helmet that is accessible to respirable gas from the remainder of the interior of the helmet makes it possible, however, to use, as the respirable gas, a gas different from that used in the diving suit, and therefore to select the most suitable gas for each purpose. Thus, for example, it is possible to use a mixture of oxygen and helium as the respirable gas, although this mixture is not suitable for use in the suit because of its high thermal conductivity, which leads to an unduly high rate of loss of heat. In such cases, the source of gas used for inflating the suit is, preferably, compressed air.

If the diving suit is inflatable, it is possible to allow gas into the diving suit to reduce the "squeeze" effect, which is caused by the pressure of the water, experienced by the diver on descent. A cushion of gas between the body and the surroundings also increases the thermal insulation of the diving suit and, by varying the degree of inflation, the buoyancy and position of the diver underwater with respect to the vertical can be adjusted.

On descent as the ambient pressure changes the volume of a given quantity of gas in the sealing means of the helmet will also change. This change can, however, be compensated for by allowing gas to enter or leave the sealing means so as to maintain the aforesaid seal.

Advantageously, the sealing means contain some liquid, preferably, four fifths of the volume of the sealing means being occupied by liquid. This reduces the change in volume of the sealing means at depth in the water that would occur if the sealing means were filled entirely with gas. Consequently, it also reduces the volume of gas it is necessary to add to the sealing means at depth to maintain the seal, and the frequency with which it is necessary to adjust the volume of gas in the sealing means.

The gas in the sealing means may be the same as the gas that is used for respiration, but when the respirable gas is a mixture of oxygen and helium, the gas in the sealing means is preferably compressed air.

Further, one helmet can, by adjusting the amount of gas inside the sealing means, be used, in turn, by several people and equipment costs can be considerably reduced. As fine adjustment of the sealing means is possible a better fit can in general be obtained with such a helmet than with a conventional helmet produced in a standard size.

Advantageously, the sealing means comprises an inflatable ring arranged to contact and surround the face of the wearer and a pressure pad, which is preferably also inflatable, arranged to contact the back of the head of the wearer and to ensure that the face of the wearer is kept in contact with the ring so as to maintain the seal with the head.

In order to restrict the so-called "dead" space and thereby limit the partial pressure of carbon dioxide in the inhaled gases, the helmet advantageously includes an ori-nasal mask having inlet valve means located in the wall of the mask to allow inhalation of respirable gas from the said region of the interior of the helmet that is accessible to respirable gas, and a duct is provided which is arranged to allow gas exhaled into the mask to leave the helmet without passing through the said region, the duct being provided with outlet valve means. It is desirable, in this respect, that the inlet and outlet valve means be situated close together.

Preferably, the helmet is provided with a vizor that is pivotably mounted on the helmet to give access to the said region of the interior of the helmet that is accessible to respirable gas. This arrangement can greatly facilitate communication by the diver on the surface even though using an ori-nasal mask as hereinbefore described, for the diver can speak when the region is opened without having to make or disrupt any connections, and this would not be possible if, as would be essential in the absence of the aforesaid seal, a conventional mouthpiece were used. In addition, with this arrangement of the pivotably mounted vizor and the ori-nasal mask, it is possible for the diver on the surface to breathe air normally when the vizor is opened, thereby avoiding the distortion of the voice that can occur when gases such as a mixture of oxygen and helium are inhaled.

A diving helmet in combination with a diving suit constructed in accordance with the invention will now be described by way of example with reference to the accompanying drawings, in which:

Figure 1 is a perspective view of a diver wearing the diving helmet and suit;

Figure 2 is a view, partly in section, of the diving helmet on a larger scale;

Figure 3 is a perspective view on a smaller scale than Figure 2 of a part of the helmet;

Figure 4 is a perspective view on a larger scale than Figure 3 of a detail of the part of the helmet shown in Figure 3;

Figure 5 is a vertical section, on a larger scale than Figure 1 but on a smaller scale than Figures 2, 3 and 4, of a further part of the helmet and suit;

Figure 6 is a perspective view, on a larger scale than Figure 1 but on a smaller scale than Figures 2, 3 and 4, of a further part of the helmet and suit;

Figure 6 is a perspective view, on a larger scale than Figure 1 but on a smaller scale than Figures 2, 3 and 4, of a detail of the part of the suit and helmet shown in Figure 5;

Figure 7 is a vertical section through valve means of the helmet; and

Figure 8 is an axial section through valve means of the diving suit shown in Figure 1 and on a larger scale.

Referring to Figure 1 of the drawings, a diving suit, indicated generally by the reference numeral 1, is secured at its neck opening to a diving helmet, indicated generally by the reference numeral 2. The diving suit, which is made of synthetic rubber, is formed with boots 3 and is sealed to the body of the wearer at the wrists by synthetic rubber cuffs 4. A sliding clasp or zip fastener 5 positioned diagonally across the diving suit 1 enables the suit to be put on easily. The diving suit 1 is inflatable and is provided with valve means (as shown in Figure 8 and as hereinafter described) that allows communication between the interior of the diving suit 1 and a source of compressed gas (not shown).

The helmet 2 comprises (as shown in Figure 2) an inner synthetic rubber lining 6 and an outer protective rigid plastics cover 7 between which are situated two layers of plastics foam 8 and 9, respectively, sandwiching a layer of aluminium-coated plastics material 10 that serves to increase thermal insulation. A one-way relief valve 11 to relieve excess pressure within the interior of the helmet 2 is inserted in registering apertures in the lining 6 and cover 7, at the top of the helmet. The relief valve 11 allows the diving suit 1 to deflate as the ambient pressure decreases relative to the pressure within the suit.

The helmet 2 is provided with a laterally extending vizor, indicated generally by the reference numeral 12, which comprises a transparent viewing panel 13 held in a metal frame 14 by a sealing member 15 (see Figure 3). At each end of the vizor 12, there is provided a clasp 16 (see Figure 4), each clasp being pivotally connected to the vizor at one end and pivotally connected to the cover 7 of the helmet 2 at its other end. When closed, the vizor 12 is held firmly in position against the cover 7 between the sealing member 15 and the liner 6 of the helmet. Releasing the clasps 16 (thereby increasing the distance between the ends of each clasp), allows the vizor to be moved away from the cover 7

and then swing upwardly to an open position as shown in Figure 3, in which the vizor is releasably held by friction between the sealing member 15 and the cover 7.

At its neck edge the liner 6 of the helmet 2 is secured to a metal ring 17 by means of a band 18, the ring 17 being formed with an annular flange 19 (see Figures 5 and 6).

A similar metal ring 20 formed with an annular flange 21 is secured to the diving suit 1 at its neck edge by means of a band 22. The two flanges 19 and 21 are releasably secured together by means of two arcuate channel-shaped members 23, which are pivotably mounted on the flange 21 and together with a toggle-actuated clasp 24 form a clamp, both of the flanges being received within the channel of the members 23 when the clamp is fastened. A seal 25 is adhesively secured to the flange 21 on the side adjacent to the flange 19.

An inhalation conduit 26 (as shown in Figure 2) is arranged to allow respirable gas from a source (not shown) of an oxygen helium mixture to enter into the helmet 2 through an inhalation duct 27 formed in the helmet. Two non-return inhalation valves 28 and 29, respectively, are arranged in an ori-nasal mask 30 and allow respirable gas to pass through into the mask. An exhalation duct to enable gas exhaled into the mask 30 to leave the helmet 2 is provided by a tube 31a extending from the mask and a passageway 31b formed in the cover 7 of the helmet at the base of the face opening, the interior of the tube being in communication with the interior of the passageway. The passageway 31b is, in turn, in communication with an exhalation conduit 31c (see Figure 1). A non-return exhalation valve (not shown) is positioned in the tube 31a close to the inhalation valves 28 and 29 to reduce " dead " space.

An inflatable ring 32 formed in the liner 6 is provided around the edge of the face opening so as to surround and isolate a region of the helmet 2 which is adjacent to the face of the wearer and into which the inhalation duct 27 opens. The remainder of the interior of the helmet 2 is in communication with the interior of the diving suit 1. An inflatable pressure pad 33 provided at the back of the liner 6 is arranged so as to contact the back of the head of the wearer and ensure that the face is kept in sealing contact with the ring 32 during use. The ring 32 and the pad 33 each contains a volume of liquid equal to four fifths of its total volume. Two branches 34 and 35 respectively, of a duct 36 extend into the interior of the ring 32 and the pad 33, respectively, and allow communication between the interior of the ring 32 and the pad 33 above the liquid and the interior of the duct 36. The duct 36 is connected at its other end to valve means indicated generally by the reference numeral 37, as shown in Figure 7, located at the base of the cover 7.

The valve means 37 comprises a body 38 constructed of metal and formed at one end with a bore 39 a portion of which is screw-threaded to accommodate a screw-threaded end of an adaptor 40. The other end of the adaptor 40 is connected to a source of compressed gas (not shown) via a connecting tube 41. An orifice plate 42 is located in the portion of the bore 39 that is not screw-threaded, between two sealing washers 43 and 44 respectively, to restrict the gas flow into a port 45. The port 45 leads into a bore 46 formed in the side of the body 38. Within the bore 46, a ring 47 forms a seat for a first valve 48 of which the stem is secured to a knob 49 and is formed with a groove 50 containing a sealing ring 51. The portion 52 of the stem is screw-threaded, the corresponding portion of the bore 46 being similarly screw-threaded. Axial movement to the valve 48 in either direction is limited to that produced as a result of a single complete rotation of the knob 49 by means of a stop 53 on the knob 49 and a similar stop 54 on the body 38.

Movement of the valve 48 away from its seat allows the interior of the bore 46, and hence the source of gas, to be in communication with the interior of a duct 55 which, in turn, is in communication with the interior of a tubular adaptor 56 similar to the adaptor 40. One end of the adapter 56 is secured to the end of the body 58 in a bore 57 and sealed by means of a sealing ring 58, and the other end is connected to the duct 36. Hence, movement of the valve 48 downwards (as seen in Figure 7) allows gas to pass from the source into the interior of the ring 32 and the pad 33. Returning the stem 48 to its seat closes the valve.

The duct 55 has a port 59 which communicates with a further bore 60 formed in the side of the body 38. Within the bore 60, a ring 61 forms a seat for a second valve 62 of which the stem is connected to a knob 63 and is formed with a groove containing a sealing ring 64. The portion 65 of the stem is screw-threaded, the corresponding portion of the bore 60 being similarly screw-threaded. Axial movement of the valve 62 in either direction is limited in the same way as that of the valve 48 to that produced as a result of a single complete rotation of the knob 63 by means of a stop 66 on the knob 63 and a similar stop 67 on the body 38. Movement of the valve 62 away from its seat allows the interior of the bore 60 and hence the interior of the ring 32 and the pad 33 to be in communication through a port 68 with the surroundings and gas is allowed to leave. Returning the valve 62 to its seat closes the second valve.

The valve of the diving suit 1 (as shown in Figure 8), which enables the suit to be inflated, comprises a tubular valve body 69 screw-threaded at one end to accommodate one end of a tubular adaptor 70, a washer 71 being provided to form a seal between the body and the adaptor. The other end of the adaptor 70 is arranged for connection to the source of compressed gas (not shown). A bore 72 extending radially from the interior of the body 69 to the exterior is screw-threaded to accommodate one end of a tubular connector 73, the other end being in the form of a domed head provided with a sealing ring 74 and a flanged nut 75 being provided to secure the connector to a tubular adaptor 76. The adaptor 76, which is formed with a frusto-conical inlet to receive the domed head of the connector 73 so that a seal is formed by the ring 74, is secured to the diving suit 1 by means of a nut 77 and a washer 78 so that gas can pass from the connector 73 into the diving suit 1.

A valve stem 79 which is screw-threaded at one end to receive a knob 80 and a locking nut 81, is secured to a valve member 82 which seats against the body 69. Downward movement (as seen in Figure 8) of the stem 79 moves the valve member 82 away from its seat against the action of a spring 83, which acts in compression between the body 69 and the adaptor 70, and allows gas to pass from the source through axial grooves 84 and an annular recess 85 in the stem 79 to the interior of the connector 73 and from there to the interior of the suit 1. A sealing ring 86 accommodated in a groove at the base of the stem 79 adjacent to the valve member 82 helps to prevent gas leakage to or from the suit 1 when the valve is closed and a further sealing ring 87 is located in a groove above the annular recess 85.

As previously stated, the pressure relief valve 11 in the portion of the helmet 2 in communication with the interior of the suit 1 is arranged to allow the suit to deflate as the ambient pressure decreases relative to the pressure within the suit.

In operation, the helmet 2 is secured to a diving suit 1 by means of the arcuate members 23. The first valve is opened to increase the volume of the ring 32 and the pad 33 by allowing gas to enter so as to adjust the helmet to fit the head of the diver and to make a seal with the head. Gas in the region of the helmet around the face of the diver is thereby isolated from the remainder of the interior of the helmet which is in communication with, and contains the same gas as, the interior of the diving suit.

With the vizor 12 closed, desirable gas passing into the region of the helmet around the face is inhaled through the inhalation valves 28 and 29, and exhaled gases pass out of the helmet through the duct 31a and 31b. Merely lifting the vizor 12 enables the diver to breathe air normally, and thereby speak more easily, without the need to make any other adjustments or disconnect any equipment.

On descent, the diver can open the first helmet valve 48 and allow gas to enter the ring 32 and the pad 33 as the pressure increases. He can also inflate the diving suit 1 by depressing the knob 80 of the suit valve. On ascent, he can open the second helmet valve 62 so as to keep the volume of the ring 32 and the pad 33 constant and maintain the correct fit of the helmet 2. The relief valve 11 in the helmet 2 allows the suit to deflate as the ambient pressure decreases. The second helmet valve 62 is opened to deflate the ring 32 and the pad 33 to allow the helmet 2 to be removed.

WHAT WE CLAIM IS:—

1. A diving helmet which includes inflatable means arranged to form a seal around the face of a wearer, thereby isolating a region of the interior of the helmet that is accessible to respirable gas from the remainder of the interior, and valve means arranged to allow the quantity of gas in the sealing means to be regulated to vary the fit of the helmet and/or to compensate for ambient pressure changes.

2. A diving helmet as claimed in claim 1, wherein the sealing means contains some liquid.

3. A diving helmet as claimed in claim 2, wherein four fifths of the volume of the sealing means is occupied by liquid.

4. A diving helmet as claimed in any one of claims 1 to 3, wherein the gas in the sealing means is the same as the gas used for respiration.

5. A diving helmet as claimed in any one of claims 1 to 3, wherein the gas in the sealing means is compressed air.

6. A diving helmet as claimed in any one of claims 1 to 5, wherein the sealing means comprises an inflatable ring arranged to contact and surround the face of the wearer and a pressure pad arranged to contact the back of the head of the wearer and to ensure that the face of the wearer is kept in contact with the ring so as to maintain the seal with the head.

7. A diving helmet as claimed in claim 6, wherein the pressure pad is also inflatable.

8. A diving helmet as claimed in any one of claims 1 to 7, wherein the helmet includes an ori-nasal mask having inlet valve means located in the wall of the mask to allow inhalation of respirable gas from the said region of the helmet that is accessible to respirable gas, and a duct is provided which is arranged to allow gas exhaled into the mask to leave the helmet without passing through the said region, the duct being provided with outlet valve means.

9. A diving helmet as claimed in any one of claims 1 to 8, wherein it is provided with a vizor that is pivotably mounted on

the helmet to give access to the said region of the interior of the helmet that is accessible to respirable gas.

10. A combination of a diving helmet as claimed in any one of claims 1 to 9 with a so-called " dry " diving suit in which, in use, allows communication between the interior of the suit is in communication with the said remainder of the interior of the helmet and not with the region accessible to respirable gas.

11. A combination as claimed in claim 10, wherein the diving suit is inflatable, and wherein there is provided additional valve means which, in use, allows communication between the interior of the diving suit and a source of compressed gas, and is also capable of allowing gas to pass from the interior of the diving suit to the exterior.

12. A combination as claimed in claim 11, wherein the said valve means includes a pressure-sensitive valve arranged to allow gas to pass from the interior of the diving suit to the exterior when the pressure of the gas in the diving suit exceeds the ambient pressure by a predetermined amount.

13. A combination as claimed in claim 12, wherein the pressure-sensitive valve is located in the diving helmet.

14. A combination as claimed in any one of claims 11 to 13, wherein the source of compressed gas is the source of gas used for respiration.

15. A combination as claimed in any one of claims 11 to 13, wherein the source of compressed gas is a source of compressed air.

16. A diving helmet substantially as hereinbefore described with reference to and as shown in the accompanying drawings.

17. A combination of a diving helmet and a diving suit substantially as hereinbefore described with reference to and as shown in the accompanying drawings.

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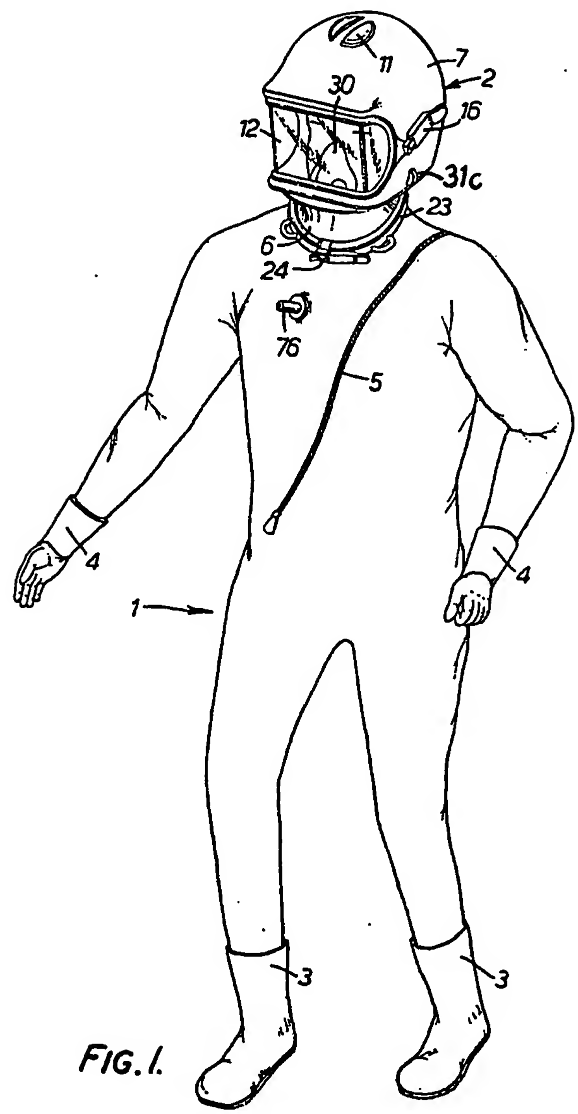

FIG. 1.

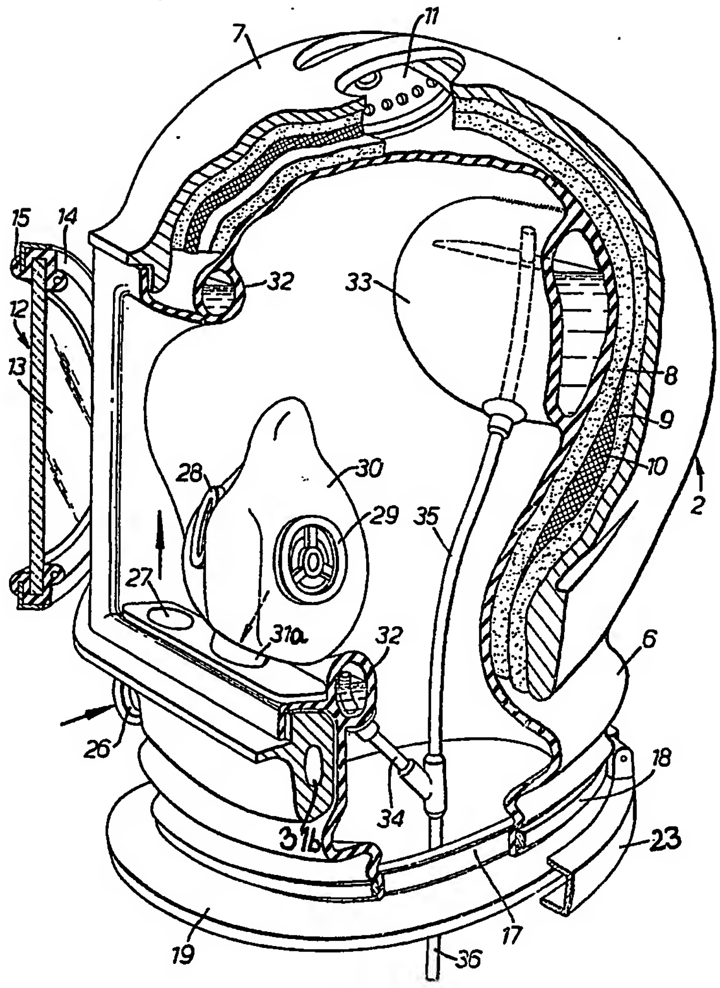
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FIG. 2.

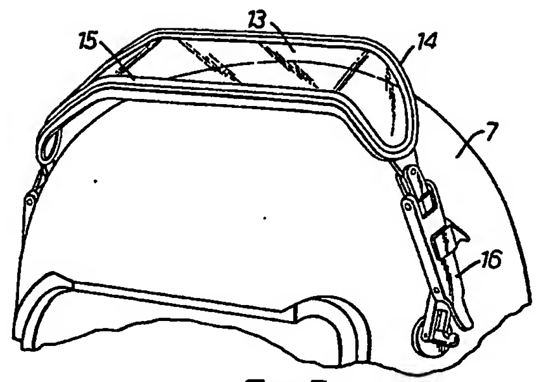

FIG. 3.

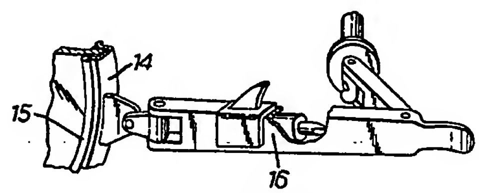

FIG. 4.

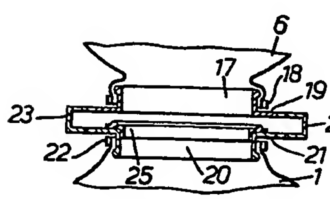

FIG. 5.

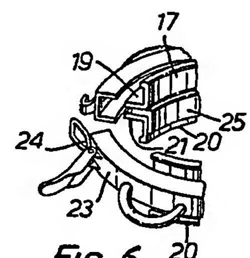

FIG. 6.

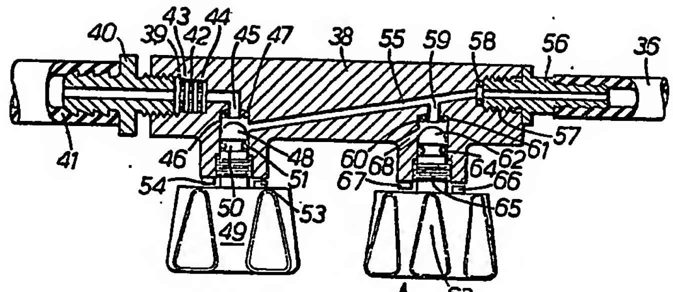
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FIG. 7.

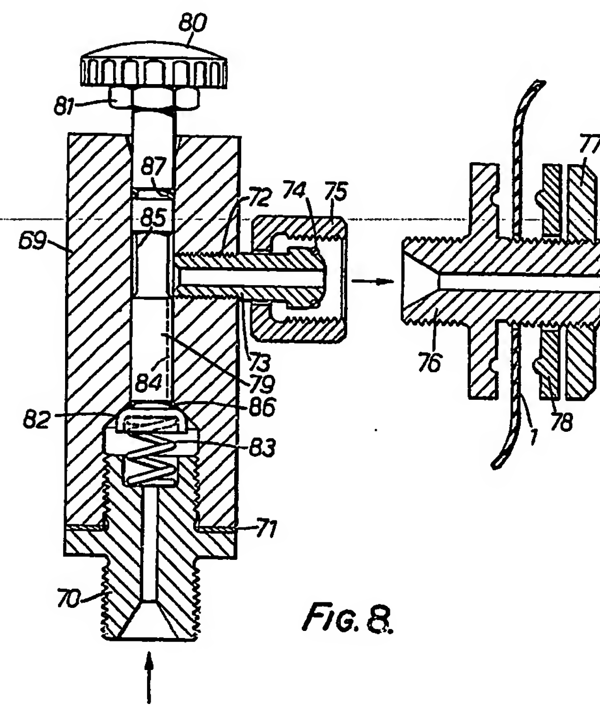
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FIG. 8.